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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Improvements in or relating to the Treatment of Cutting Edges

We, WILKINSON SWORD LIMITED, a British Company, of 16, Pall Mall, London, W.1, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the provision of polymer coatings on or adjacent cutting edges.

Examples of cutting edges which may be treated in this way are the whole or part of razor blades, hypodermic needles, surgical scalpel blades, culinary knives and garden tools. Such polymer coatings are applied to reduce the force necessary to produce a given out and generally to provide improved cutting effectiveness.

According to the invention there is provided the method of forming a polymer coating on or adjacent a cutting edge which comprises passing a glow discharge through a monomer (as herein defined) whilst the monomer is in the gaseous phase and causing deposition to form the polymer coating.

Polymerisation can occur either in the gas phase or on the substrate surface, or both.

The term "monomer" as used herein is intended to embrace any compound which, under the action of a glow discharge, can be caused to form a polymer. Thus the term includes compounds which are normally regarded as monomers because they can be caused to polymerise by conventional methods, for example ethylene. However, in the present context the term also includes compounds which it may be difficult to cause to form polymers by conventional methods but which can be caused to form polymers or substances having properties equivalent to polymers by means of the present invention, for example 1-hydroperfluoropropane. In this respect it should be appreciated that polymers produced under glow discharge conditions in accordance with the present invention are not necessarily identical to those produced by conventional polymerisation methods. Because polymers produced by the present invention normally exist as thin films examination is difficult but it has been noted, for example, that the infra-red absorption spectra of polymers produced from ethylene and from tetrafluoroethylene are not identical to the corresponding absorption spectra of commercially obtainable samples of these polymers, even though the corresponding pairs of spectra have many similar characteristics. Examples of monomers which may be used to form a polymer coating by glow discharge are hydrocarbons, particularly aliphatic hydrocarbons and their halogen derivatives, and more especially the fluorine substituted hydrocarbons and their halogen derivatives. Other examples are silicones, particularly alkylsiloxanes.

One construction of apparatus by which the present invention may be performed will now be described, by way of example, with reference to the accompanying drawing which is a sectional side elevation of the apparatus.

Referring to the drawing it will be seen that the apparatus comprises a generally cylindrical body 10 closed at each end by end plates 11,12 through which extend conductive supports 13,14 carrying internal electrode plates 15,16. The spacing between the electrode plates 15,16 can be adjusted by movement of the supports 13,14 relative to their respective end plates 11,12.

A stack of articles, for example razor blades, having one or more cutting edges on

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or adjacent which a polymer coating is to be formed are located at 17. Of course, a single article could be so positioned if desired.

Monomer gas is admitted into the body 10 through a jet 18 under the control of an inlet valve 19 and the gas is exhausted through the outlet 20 which is connected to a vacuum-pump (not shown) via a control valve 21. If desired a circulating pump may be used to effect continuous circulation of the gas, preferably with a gas reservoir admitting fresh monomer and with means at the extraction end for condensing out undesirable by-products.

A typical partial pressure of the monomer gas is from 0.01 to 200 millimetres of mercury. The monomer gas may be used alone or with a diluent gas, for example an inert gas such as argon.

For production of a glow discharge within the chamber the electrodes may be connected to a direct current or alternating current source. However, it is preferred to use a high frequency alternating current source, for example within the range of about 100 kc/s to 2 mc/s. A subsidiary potential may be applied to the stack of objects in order to attract the molecules to be deposited thereon.

The chamber may be constructed from an electrical insulating material for example glass or an appropriate polymer, for example polypropylene, the chamber being made vacuum tight by the use of appropriate seals.

As an alternative to forming the glow discharge between the electrode plates the articles on which the coating is to be formed may themselves be made one of the electrodes between which the glow discharge is formed. In the case of very fine cutting edges, such as those of razor blades, it may be desirable to use frequencies at the higher end of the suggested frequency range. The articles may themselves serve as both of the electrodes.

As an alternative to having the articles stationary they may be moved through the apparatus entering at an inlet 22 and leaving at an outlet 23, each of which is provided with appropriate vacuum seals (not shown). For such operation it is preferred to use external electrodes 24,25 rather than the internal electrodes 15,16 and these external electrodes may conveniently be provided by a conductive band on the exterior of the chamber. Alternatively an external electrode at either end of the chamber can be used with an internal electrode at the opposite end of the chamber.

The glow may be continuous or intermittent. When the operation is being run on a batch basis the glow may be continuous for short predetermined periods, for example from half a second to 30 seconds. Provision can be made for dissipation of heat from the chamber by the use of cooling fins or by the use of an appropriate cooling medium.

After coating, articles may be left in an inert atmosphere for several hours and/or left in the monomer vapour for a similar period. Subsequent heat treatment may be applied but the process does not require the use of such high temperatures as would normally cause undesirable change in the mechanical properties of the article being coated. Thus, in the case of razor blades the heating need not be such as would result in an undesirable reduction in the hardness of the cutting edge.

The preferred order of thickness of polymer coating is from 0.0025 to ten microns.

The following are examples of the method of performing an invention using the above described apparatus:—

Example I

Using the apparatus shown in the drawing and employing the external electrodes a glow discharge is formed in an atmosphere of 1-hydroperfluoropropane at 1.4 millimetres of mercury using a high frequency source of 140 Kc/s. Having ascertained the position of the glow path the energy source is disconnected whilst a stack of 350 double-edge wafer razor blades is placed adjacent the area of glow and with one set of cutting edges parallel to and facing the axis of the cylindrical apparatus and 3 centimetres from the nearest point where the glow path has been observed.

The glow discharge is then re-established and maintained for 30 seconds by the end of which period the glow path will have extended and will appear to be touching the nearest set of cutting edges.

On removal from the apparatus the blades will show faint interference patterns on those edges which have been adjacent to the glow discharge and these edges will be found to provide a more comfortable shave than those which have been remote from the discharge path.

Example II

Using the apparatus in the same manner as Examples I a glow discharge is struck through dibromodifluoromethane at a pressure of 5.5 millimetres of mercury. As in the previous example the edges which have been adjacent the discharge path will be found to afford more comfortable shaves than those which were remote from the discharge path.

Example III

The method of the previous Example is used except that the monomer is admitted continuously through the inlet and pumped away from the outlet, the flow rate being controlled so that the measured pressure in the apparatus is 2.4 millimetres of mercury. Once again the edges adjacent the glow dis-

charge will be found to provide more comfortable shaves than the edges which were remote from the glow discharge.

EXAMPLE IV

The apparatus in this instance is provided with two electrodes, which have been sharpened to knife edges, placed parallel to one another with their flat surfaces 5.5 centimetres apart. Using ethylene at a pressure of 1 millimetre of mercury a 400 cycles per second source is applied to the electrodes, a glow being struck at a measured potential of 900 volts. The flow is maintained for 5 seconds during which time the measured current flowing should be of the order of 85 milliamps. It will be found that both facets of each knife edge have been coated with a pale yellow adherent film and that a reduced force is required to make a standard cut.

The theory of polymerisation by glow discharge in accordance with the present invention is not fully understood and whilst the applicants do not wish to be bound by any theory of operation it appears that three main processes can operate:—

(1) A monomer of conventional type, such as ethylene, tetrafluoroethylene or hexafluoropropylene, is excited by the conditions in the glow, and excited molecules can then either initiate a conventional addition polymerisation or be the sole or main species which give rise to polymerisation. Such polymerisation can take place either in the gas phase or on the substrate surface, or by a combination of both processes.

(2) The monomer undergoes scission in the glow discharge and a product of scission is then capable of forming a polymer. Usually, the product of scission forms as a di-free radical or as a carbene or similar species. Thus, Example IV probably proceeds by this mechanism, the dibromodifluoromethane when subjected to the glow discharge forming difluorocarbene, which then under these conditions polymerises.

$$CF_2Br_2 \rightarrow CF_2 + 2 . Br$$

It appears that, in reactions of this type, most of the polymerisation process takes place on the substrate.

(3) The monomer undergoes scission to form a monomer of conventional type, this compound then undergoing polymerization as under (1) above. It appears that 1-hydroperfluoropropane undergoes polymerisation by this route.

WHAT WE CLAIM IS:—

1. The method of forming a polymer coating on an article having a cutting edge, wherein a gas of a monomer of the compound from which the polymer coating is to be formed is treated by passing a glow discharge through the gas and the treated gas contacts the article and deposits thereon to form the polymer coating.

2. The method of forming a polymer coating on an article having a cutting edge, wherein a monomer which is in the gaseous phase is polymerised by establishing a glow discharge through the monomer gas, polymerised gas depositing on the article to form the polymer coating.

3. The method of coating a cutting edge of an article with a polymer, comprising the steps of placing the article in a gas containing a monomer from which the polymer can be formed, and establishing a glow discharge in the gas adjacent the article, treated gas depositing on the cutting edge to form the polymer coating.

4. The method of forming a coating of a polymer on a cutting edge of an article which comprises the steps of placing the article in a gaseous mixture composed of a gaseous monomer from which the polymer can be formed together with an inert diluent gas, the partial pressure of said gaseous monomer being not greater than 200 millimetres of mercury, establishing a high frequency alternating current glow discharge through said gas, and causing the gaseous mixture to flow past said article whereby a polymer coating is deposited on said cutting edge.

5. The method according to any one of the preceding claims, wherein an electrical potential difference is established between the article and at least one electrode employed for the establishment of the glow discharge.

6. The method according to any one of the preceding claims, wherein the gaseous monomer is a hydrocarbon.

7. The method according to any one of claims 1 to 5, wherein the gaseous monomer is a halogen derivative of a hydrocarbon.

8. The method according to any one of claims 1 to 6, wherein the gaseous monomer is an aliphatic hydrocarbon.

9. The method according to any one of claims 1 to 5, wherein the gaseous monomer is a fluorine substituted hydrocarbon.

10. The method according to any one of claims 1 to 5, wherein the gaseous monomer is a halogen derivative of an aliphatic hydrocarbon.

11. The method according to any one of claims 1 to 5, wherein the gaseous monomer is a halogen derivative of a fluorine substituted hydrocarbon.

12. The method according to any one of claims 1 to 5, wherein the gaseous monomer is a silicone.

13. The method according to claim 12,

wherein the gaseous monomer is an alkylsiloxane.

14. The method of forming a polymer coating substantially as herein described.

15. An article having a cutting edge coated by the method according to any one of claims 1 to 14.

16. A razor blade, a cutting edge of which has been coated by the method according to any one of claims 1 to 14.

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1 SHEET This drawing is a reproduction of the Original on a reduced scale